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July 11, 1996

Mr. Claude Mayer
3 SPTG/CEVR
22040 Maple Street
Elmendorf AFB, Alaska 99506-3240

Subject: Results of Additional Bioventing Respiration Testing at Sites ST61, ST71, and ST43/55 (Pumphouse III and Valve Pit 3-4), performed under Contract No. F41624-92-8036, Order 17.

Dear Claude:

Parsons Engineering Science, Inc. (Parsons ES) is pleased to submit the results of additional bioventing respiration testing at Sites ST61, ST43/55 (Pumphouse III and Valve Pit 3-4), and ST71, Elmendorf Air Force Base (AFB), performed during the period of May 23-28, 1996 at the 3-year milestone (i.e., 3 years of continuous pilot-scale system operation). Two important tasks were accomplished during this field event: 1) an *in situ* respiration test was conducted to determine the current rates of oxygen utilization at each site, and 2) oxygen influence measurements were collected to confirm that the expected treatment area is receiving oxygen at the current air injection flow rate. No laboratory soil gas sampling was performed at the sites.

INTRODUCTION

Project Overview

Initial bioventing pilot tests were completed by Parsons ES at four sites at Elmendorf AFB, Alaska during the period from June 15 through July 19, 1993 (ES, 1993). Vent well and monitoring point construction, respiration and air permeability testing, soil and soil gas sampling, and blower system installation and startup was performed at each site as part of the initial testing. To monitor remedial progress, 6-month and 1-year respiration testing was performed, and 1-year soil and soil gas sampling was completed.

In September 1994, Parsons ES was awarded a task order from AFCEE (contract F41624-92-D-8036 Order 17) to complete remediation monitoring and design and/or closure sampling, and to implement full-scale bioventing at several US Air Force sites. The purpose of the new task order is to extend the operation of existing bioventing pilot systems, and to move forward with either site closure or design and implementation of full-scale bioventing systems. Four potential options were identified for each site.

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- Option 1 - An additional 1 year of testing for existing bioventing systems;
- Option 2 - Closure soil sampling for sites which have demonstrated bioventing success;
- Option 3 - Complete an initial bioventing test at a new site; and
- Option 4 - Design and installation of a multiple-vent well, full-scale bioventing system.

Parsons ES is contracted to perform an Option 1 task at Sites ST61, ST43/55-Pumphouse III, and ST43/55-Valve Pit 3-4, and an Option 2 task at Site ST71. Under Option 1, Parsons ES is responsible for the following:

- 1) Any major system repairs required over 1 year of extended system operation beginning on August 9, 1995 (No repairs have been required to date).
- 2) Collecting laboratory soil gas samples for the analysis of total volatile hydrocarbons (TVH) and benzene, toluene, ethylbenzene, and xylenes (BTEX) from the same monitoring point intervals that were sampled during the initial and 1-year sampling events (Performed in October 1995).
- 3) Performing one respiration test at the same monitoring points that were tested during the initial and 1-year sampling events (Two tests were performed, one each during the October 1995 and May 1996 field events).
- 4) Providing AFCEE with a letter report summarizing the extended bioventing test results (Delivered on December 6, 1995).

Under Option 2, Parsons ES is responsible for the following:

- 1) Preparing a closure sampling and analysis plan (SAP) (Final SAP was delivered on April 12, 1996).
- 2) Performing closure soil sampling to demonstrate that site cleanup goals have been achieved (Performed on May 28, 1996).
- 3) Preparing a soils "no further response action planned" decision document or a letter report summarizing sampling results (To be delivered August 16, 1996).

TEST PROCEDURE

The 1-horsepower regenerative air injection blowers at Site ST61, Valve Pit 3-4, and Pumphouse III were operating upon arrival. Soil gas oxygen influence measurements were taken at each of the previously oxygen deficient vapor monitoring points (MPs) from each site. Following the oxygen influence measurements the blowers were shut down and oxygen, carbon dioxide, and TVH levels were monitored for 4 days from select MPs.

At Site ST71, the blower was shut down approximately 1 month prior to closure soil sampling and respiration testing to allow the soil gas to reach equilibrium with the soils. Following initial soil gas sample collection, air was injected into MPB using 1-standard-cubic-foot-per-minute (scfm) pumps for approximately 20 hours. At the end of the 20-hour injection period, the air supply was cut off, and oxygen, carbon dioxide, and TVH levels were monitored for 3 days. The decline in oxygen over time was used to estimate rates of bacterial degradation of fuel residuals. Additional details on the *in situ* respiration test procedures are provided in Section 5.7 of the protocol document (Hinchee *et al.*, 1992).

RESULTS

In general, respiration rates at Elmendorf AFB sites have decreased since initial testing was completed in July 1993. A reduction in the oxygen utilization rates and hydrocarbon degradation rates after bioventing is often observed, and can be caused by several factors including: (1) the lighter, more readily degraded hydrocarbons have been degraded during the initial months of bioventing; and (2) the remaining hydrocarbons typically are more difficult to degrade and result in decreased oxygen utilization. The recent testing at Site ST61, Valve Pit 3-4, and Pumphouse III is comparable to the 6-month respiration testing conducted in January 1994, however, it is not comparable to the initial (7/93), 1-year (8/94), and 2-year (10/95) respiration tests (which were conducted during the same season), because the 6-month and 3-year testing was started immediately after shutting off the blower. This procedure is known as an "area" respiration test. The importance of knowing the oxygen influence from the blower preceded the need for comparable data at this time. The recent testing at Site ST71 is comparable to the initial (7/93), 1-year (8/94), and 2-year (10/95) respiration tests because the testing was similarly performed after a 1 month system shut-down. During each test air was injected directly into each MPB interval prior to performing a "point" respiration test.

Site ST61

Site ST61, currently the location of a Navy operations facility, was formerly a vehicle maintenance facility (Attachment A, Figure A.1). Wastes generated at the site may have included waste oil, solvents, paints, and fuels. Details of site conditions and the initial pilot test are contained in the Pilot Test Interim Results Report (ES, 1993).

During the period of May 23-28, 1996, an *in situ* respiration test was performed to determine the continued rates of oxygen utilization at the site. Results of each *in situ* respiration test conducted to date, and the corresponding hydrocarbon degradation rates are summarized in Table A.1. Respiration rates in May 1996 at contaminated monitoring points ranged from 0.0008 to 0.0054 percent oxygen utilized per minute (%/min). The corresponding biodegradation rates ranged from 170 to 650 milligrams of fuel per kilogram of soil per year (mg/kg/year). Based on the results of this test, a significant amount of fuel residuals still remains in soils at this site, and biodegradation of these residuals is still occurring at significant rates. The lowest rate of oxygen utilization was measured at the vent well (0.0008 %/min). This is consistent with past measurements and is indicative of the relatively low level of hydrocarbon contamination initially measured at the vent well. MPA-4 (Figure A.1) exhibited the greatest oxygen demand,

indicating that significant biodegradation of fuel residuals is occurring. Based on the 1-year soil sampling results, high concentrations of fuel hydrocarbons still existed at this location.

Because of the low-permeability soils at this site, short circuiting of the injected air has been observed in the past. Following system startup on May 28, 1996 water was sprayed on the asphalt near the VW to see if air was still short circuiting, and short circuiting was not observed (air bubbles at the asphalt surface). Navy personnel at Classic Owl (Building 52-140) stated that they had not noticed any air bubbles in the past year. Oxygen influence measurements at MPA confirmed that oxygen influence is still being delivered to soils within the area of contamination.

Site ST43/55-Pumphouse III

Site ST43/55-Pumphouse III, is located north of Pumphouse III (Building 42-103) (Attachment B, Figure B.1). Details of the initial pilot test are contained in the Pilot Test Interim Results Report (ES, 1993).

During the period of May 23-28, 1996, an *in situ* respiration test was performed to determine the continued rates of oxygen utilization at the site. Results of each *in situ* respiration test conducted to date, and the corresponding degradation rates, are summarized in Table B.1. Respiration rates at contaminated monitoring points ranged from 0.0008 to 0.0011 %/min. The corresponding biodegradation rates ranged from 110 to 270 mg/kg/year. Based on the results of this test, a significant amount of fuel remains in soils at this site, and biodegradation is occurring at significant rates. A lower rate of oxygen utilization was measured at each MP as compared to initial, 1-year, and 2-year results, however the rates are comparable to the January 1994 test, which was also an "area" respiration test. This decreasing trend is consistent with observations made at many other bioventing sites. Typically, as readily degradable hydrocarbon concentrations decrease, so do oxygen utilization rates.

Site ST43/55-Valve Pit 3-4

Site ST43/55-Valve Pit 3-4, is located east of Pumphouse III (Building 42-103) and immediately north of Valve Pit 3-4 (Attachment C, Figure C.1). Details of site conditions and the initial pilot test are contained in the Pilot Test Interim Results Report (ES, 1993).

During the period of May 23-28, 1996, an *in situ* respiration test was performed to determine the continued rates of oxygen utilization at the site. Results of each *in situ* respiration test conducted to date, and the corresponding hydrocarbon degradation rates are summarized in Table C.1. Respiration rates at contaminated monitoring points ranged from 0.00021 to 0.0026 %/min and biodegradation rates ranged from 60 to 760 mg/kg/year. Based on the results of this test, a significant amount of fuel residuals remains in soils at this site, and biodegradation of these residuals is occurring at significant rates. Although not completely comparable, significantly lower rates of oxygen utilization were measured at the VW and MPB as compared to the initial, 1-year,

and 2-year "point" respiration test results. This decreasing trend is consistent with observations made at many other bioventing sites, as discussed above.

Site ST71

Site ST71, currently the location of the vehicle maintenance shop building (31-338), is the location of a former 500-gallon underground storage tank (UST) that was used to store primarily diesel and JP-4 fuels (Attachment D, Figure D.1). Details of site conditions and the initial pilot test are contained in the Pilot Test Interim Results Report (ES, 1993).

During the period of May 24-28, 1996, an *in situ* respiration test was performed to determine the continued rates of oxygen utilization at the site. Results of each *in situ* respiration test conducted to date, and the corresponding hydrocarbon degradation rates are summarized in Table D.1. Respiration rates at MPB-4 and MPB-10 ranged from 0.00006 to 0.00016 %/min, respectively. The corresponding biodegradation rates ranged from 20 to 45 mg/kg/year. Based on the results of this test, minimal amounts of fuel remain in soils at this site, and biodegradation of these residuals was occurring at extremely slow rates, prior to system shut-down and closure soil sampling.

Laboratory soil samples were collected from Site ST71 during this field mobilization. During August 1996, Parsons ES will submit a draft closure soil sampling results report.

RECOMMENDATIONS

Based on the respiration testing and soil gas sampling results from Sites ST61 and ST43/55 (Pumphouse III and Valve Pit 3-4), it is recommended that all three bioventing systems remain in operation. A significant amount of residual fuel remains in soils at each site, and biodegradation of these residuals is still occurring at significant rates.

Although limited data is available for Site ST61, it is expected that the system at ST61 is providing full-scale treatment of impacted soils. Because significant oxygen utilization was observed at this site, particularly at MPA-4, continued operation is recommended. Annual respiration tests should continue, and soil sampling should be performed after oxygen utilization rates approach background rates. The short circuiting problem that was observed in the past appears to have subsided. It is possible that preferential subsurface air pathways have been developed over the past two years, thus allowing less air flow to the surface.

Since monitoring well AP-3566 (which was used as an MP) was abandoned recently it is recommended that an additional MP be installed near the former location of well AP-3566 or immediately south of the blower shed at Site ST61. Since the blower shed is located in a grassy area it may not be desirable to drive a heavy drill rig over the grass. An additional MP would also provide more soil analytical data that may further characterize the current site conditions.

Bioventing systems at the Pumphouse III and Valve Pit 3-4 sites are treating only a portion of larger contaminated soil volumes. Continued operation will continue to

facilitate biodegradation of fuel hydrocarbons within the treatment area or transported into the treatment area. However, treatment of the entire contaminated soil volume will require installation of full-scale systems. Based on results from testing at Pumphouse III, the estimated radius of oxygen influence at Site ST43/55 is 60 feet. A review of existing data from the Final Corrective Action Plan (ENSR, 1995) indicates that a 2.5 to 5 foot thickness of soil contamination is present above the groundwater table throughout the site. Considering such, it is recommended that additional VWs and MPs be installed at the site. Limited data is available to ascertain an optimal remedial action for the entire site, however, a conceptual bioventing remedial design for the area near both existing systems is included in Attachment B (Figure B.2). The recommended VW screened intervals are also included on Figure B.2. Ideally, three additional VWs could be plumbed to the blower at Valve Pit 3-4, and two more VWs could be plumbed to the Pumphouse III blower. Flow rates should range from 10-15 standard cubic feet per minute (scfm). Additionally, it is important to monitor soil gas in areas where the radii of oxygen influence intersect. Soil gas in these areas may become stagnant due to air pressure from opposite directions. Discrete vapor MPs should be screened near the water table (approximately 16.5-20 feet below ground surface). Converting the recommended soil borings to MPs should also be considered.

If the Alaska Department of Environmental Conservation (ADEC) continues to require a non-risk-based/TPH cleanup, the pilot- or full-scale bioventing systems should be operated until respiration rates approach background rates. We recommend that confirmatory soil sampling be conducted 4 to 6 months after background respiration rates are approached. If ADEC converts to a risk-based/BTEX standard, the sites could be closed much sooner.

If you have any questions or require any additional information, please contact me at (303) 831-8100.

Sincerely,

PARSONS ENGINEERING SCIENCE, INC.



David Teets
Site Manager

Attachments

1. Site ST61 Data
2. Site ST43/55-Pumphouse III Data
3. Site ST43/55-Valve Pit 3-4 Data
4. Site ST71 Data

cc: AFCEE/ERT (Capt Ed Marchand)
File 726876.41210 Letter Results Report

ATTACHMENT A
SITE ST61

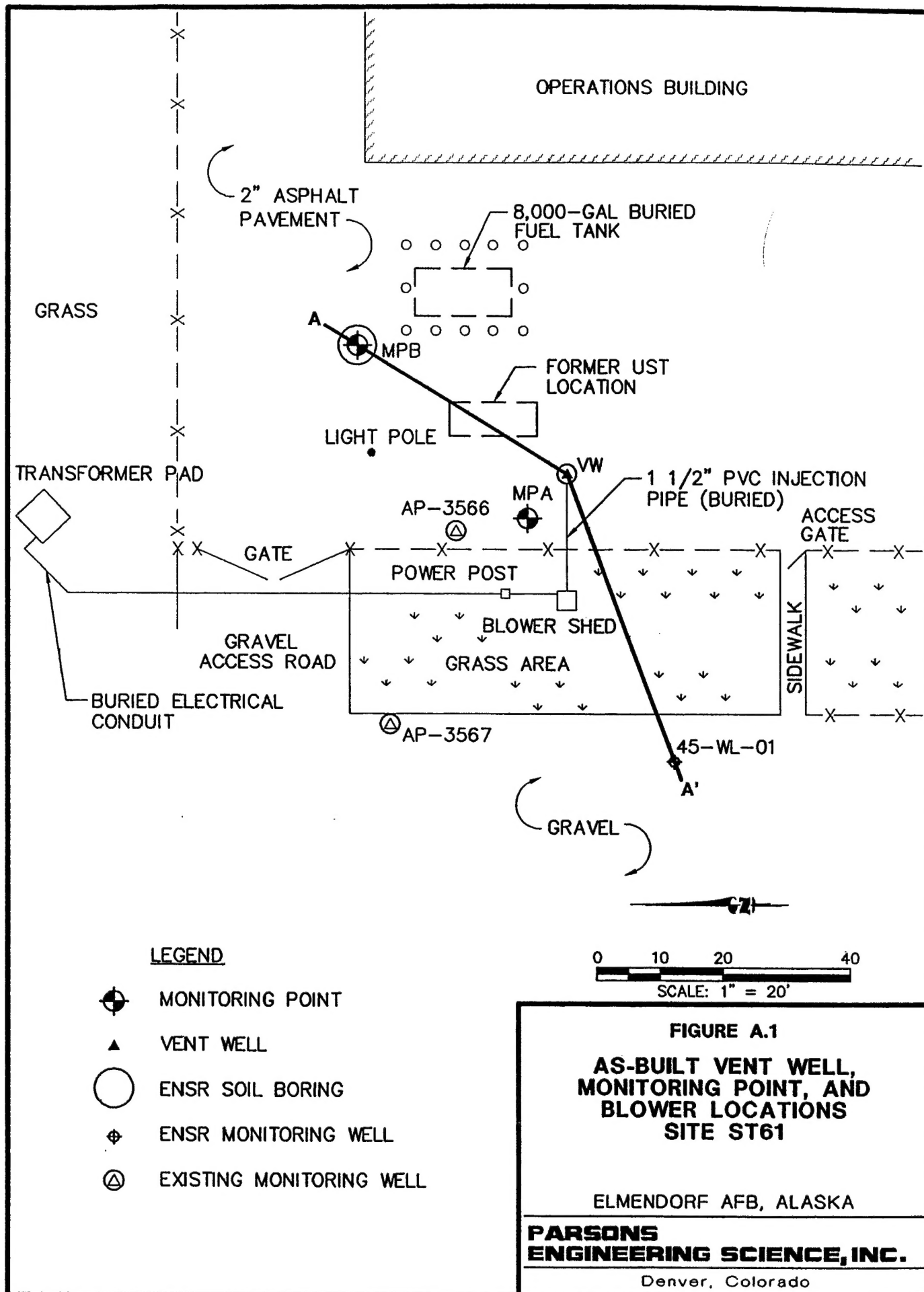


TABLE A.1
ST61
RESPIRATION AND DEGRADATION RATES
ELMENDORF AFB, ALASKA

Location-Depth	Initial (July 1993)		6-Month ^{b/} (January 1994)		1-Year (August 1994)		2-Year ^{b/} (October 1995)		3-Year ^{b/} (May 1996)	
	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year) ^{a/}	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)
VW (5'-20')	0.0033	770	NS ^{a/}	NS	0.00063	130	0.0011	240	0.00077	170
MPA-4	0.0015	320	0.0020	240	0.017	680	0.0093	1,130	0.00537	650
MPA-13	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
AP-3566 (?) ^{d/}	0.014	3,200	NS	NS	0.0043	960	0.0027	600	NS ^{c/}	NS
AP-3567 (?)	NS	NS	0.00040	90	NS	NS	NS	NS	NS	NS

^{a/} Milligrams of hydrocarbons per kilogram of soil per year.

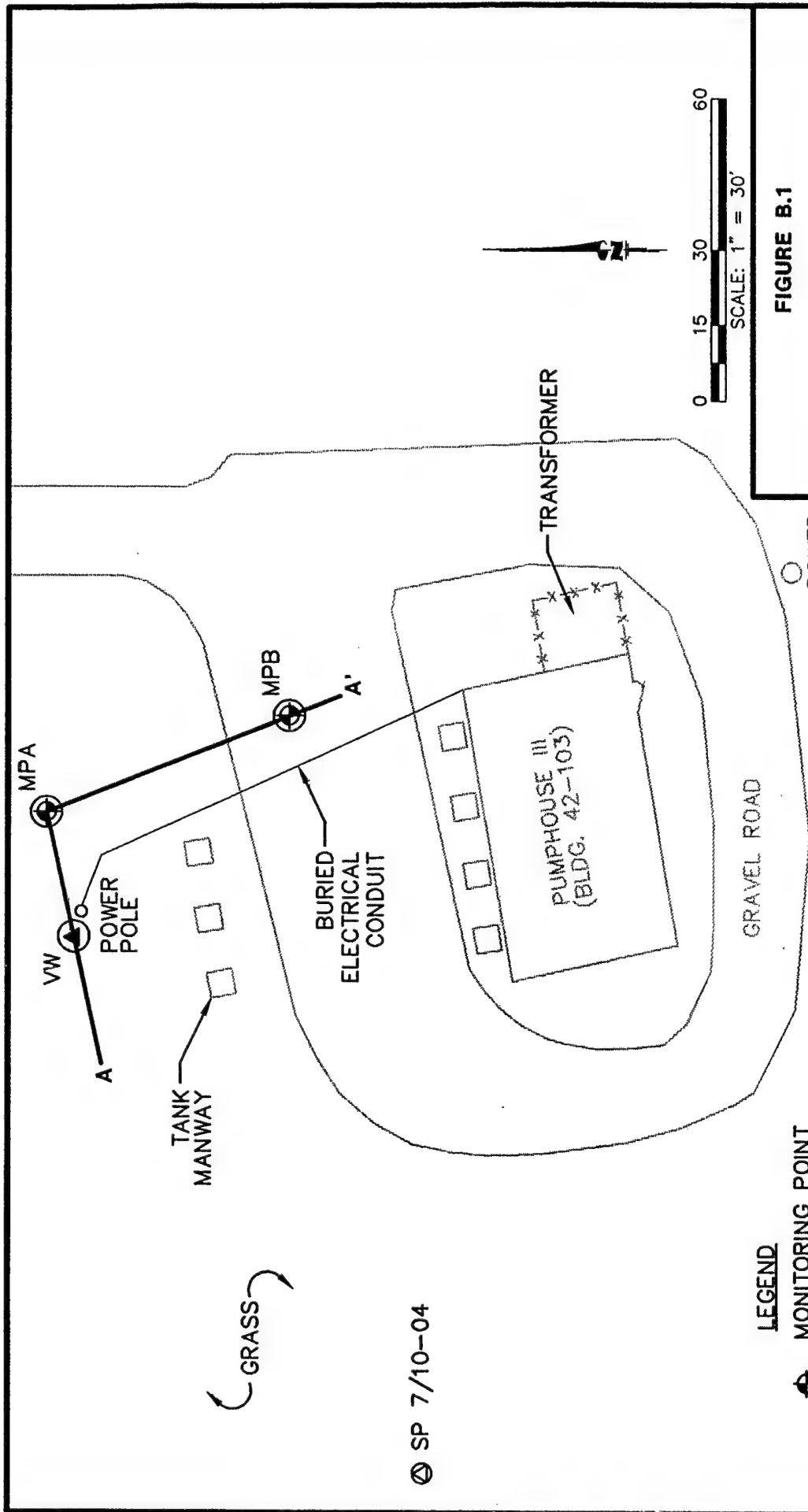
^{b/} Assumes moisture content of the soil is the average of initial and 1-year moistures.

^{c/} Not Sampled.

^{d/} ? = Screened interval is unknown.

^{e/} Monitoring well AP-3566 was abandoned.

ATTACHMENT B
SITE ST43/55 - PUMPHOUSE III



SP 7/10-04

LEGEND

- MONITORING POINT
- VENT WELL
- ENSR SOIL BORING
- EXISTING MONITORING WELL

NOTE:
THE BLOWER IS LOCATED DIRECTLY
OVER THE VENT WELL.

FIGURE B.1

AS-BUILT VENT WELL,
MONITORING POINT, AND
BLOWER LOCATIONS
PUMPHOUSE III AREA

ELMENDORF AFB, ALASKA

PARSONS
ENGINEERING SCIENCE, INC.

Denver, Colorado

TABLE B.1
ST43/55 - PUMPHOUSE III
RESPIRATION AND DEGRADATION RATES
ELMENDORF AFB, ALASKA

Location-Depth	Initial (July 1993)		6-Month ^{b/} (January 1994)		1-Year (August 1994)		2-Year (October 1995)		3-Year ^{b/} (May 1996)	
	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year) ^{a/}	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)
VW (15'-23')	0.0078	1,700	NS ^{d/}	NS	0.0017	490	0.00084	240 ^{c/}	NS	NS
MPA-19	0.0066	1,100	0.0013	180	0.0045	500	0.0052	700 ^{b/}	0.00079	110
MPB-19	0.011	3,100	0.0017	400	0.0096	1,800	0.0041	950 ^{b/}	0.00114	270

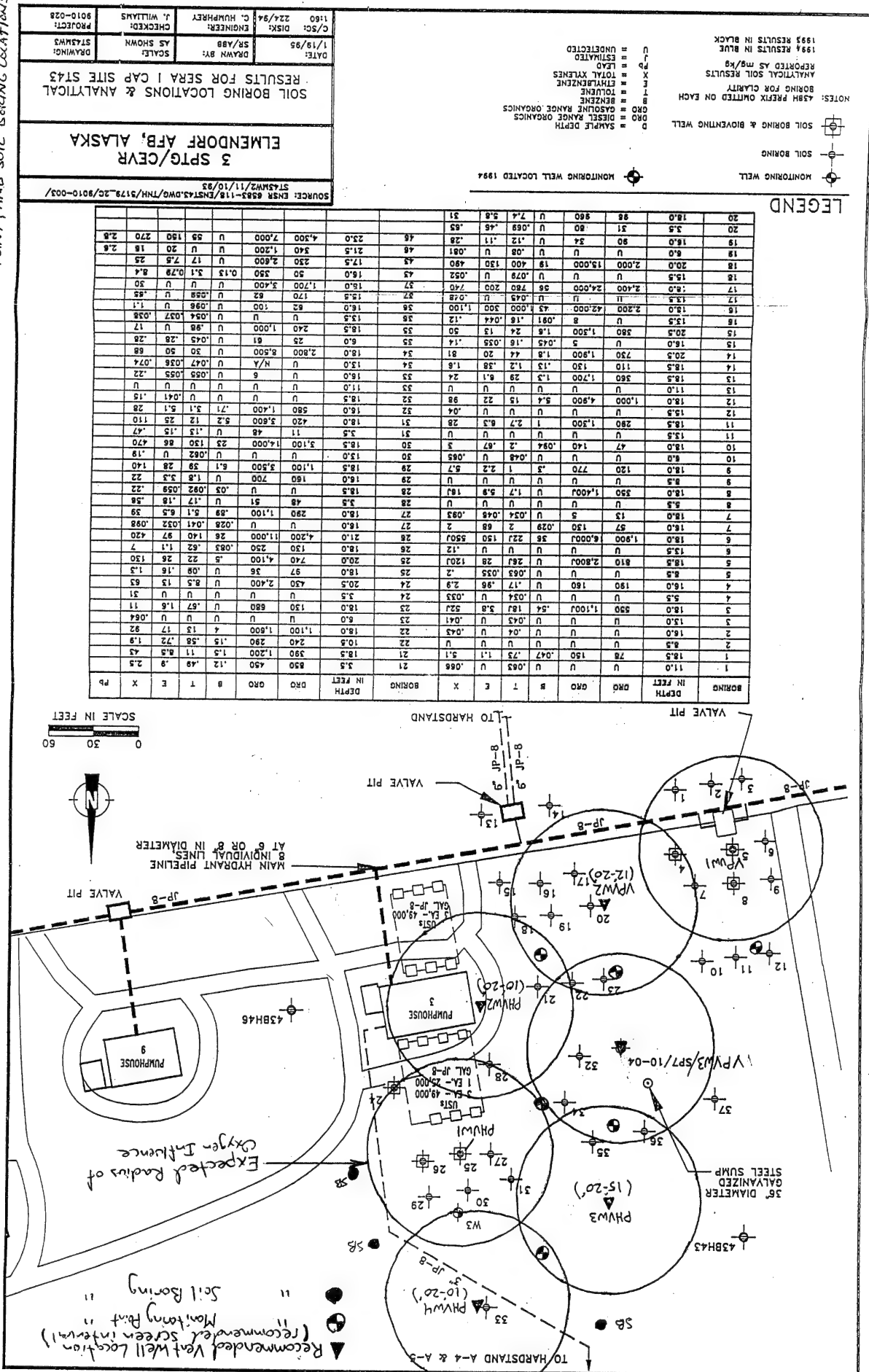
^{a/} Milligrams of hydrocarbons per kilogram of soil per year.

^{b/} Assumes moisture content of the soil is the average of initial and 1-year moistures.

^{c/} Assumes moisture content of the soil is the same as the 1-year moisture.

^{d/} Not Sampled.

Figure B.2
RECOMMENDED VENT WELL MONITORING
POINT, AND SOIL BORING LOCATIONS



ATTACHMENT C
SITE ST43/55 - VALVE PIT 3-4

TO SP 7/10-04

GRASS AREA

A

MPA

MPB

A'

VW

BURIED ELECTRICAL CONDUIT

VALVE PIT 3-4

EXISTING POWER POLE AND BREAKER BOX WITH 5 KVA TRANSFORMER AND BREAKER BOX FOR BIOVENTING SYSTEM

CONCRETE AIRCRAFT RAMPS

ASPHALT ACCESS ROAD

LEGEND



MONITORING POINT



VENT WELL



ENSR SOIL BORING

NOTE:
THE BLOWER IS LOCATED DIRECTLY
OVER THE VENT WELL.



FIGURE C.1

**AS-BUILT VENT WELL,
MONITORING POINT, AND
BLOWER LOCATIONS
VALVE PIT 3-4 AREA**

ELMENDORF AFB, ALASKA

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Denver, Colorado

TABLE C.1
VALVE PIT 3-4
RESPIRATION AND DEGRADATION RATES
ELMENDORF AFB, ALASKA

Location-Depth	Initial (July 1993)		6-Month ^{b/} (January 1994)		1-Year (August 1994)		2-Year ^{b/} (October 1995)		3-Year ^{b/} (May 1996)	
	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year) ^{a/}	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)
VW (15'-22')	0.0051	1,430	NS ^{d/}	NS	0.0016	430	0.00093	260	0.00021	60
MPA-12.5	NS	NS	0.00011	30	NS	NS	NS	NS	NS	NS
MPA-16.5	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
MPB-12.5	0.0063	1,800	NS ^{d/}	NS	0.0013	420	0.0025	710	0.00028	80
MPB-16.5	0.0054	1,500	NS ^{d/}	NS	0.0050	1,600	0.0054	1,600	0.00261	760

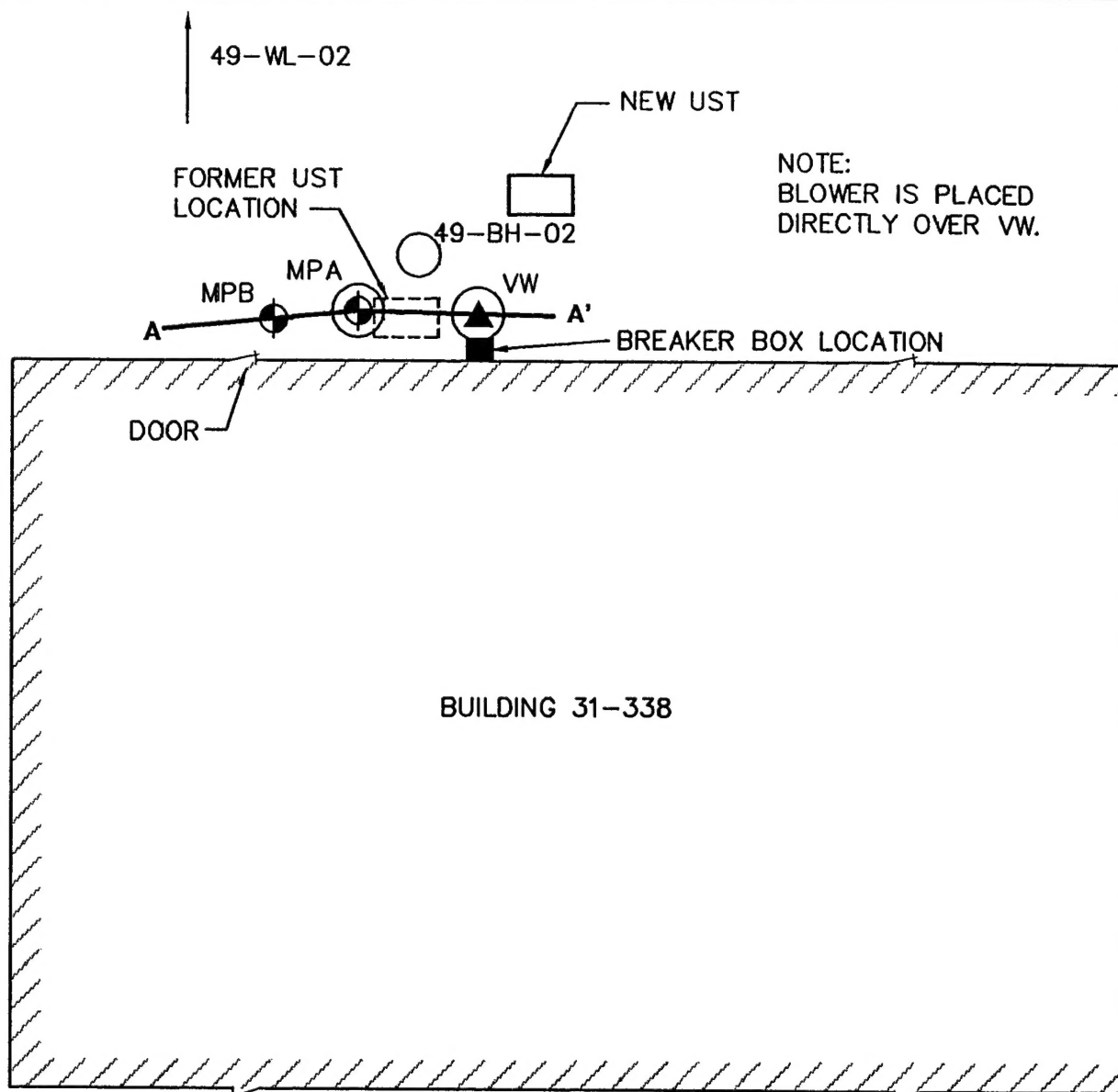
^{a/} Milligrams of hydrocarbons per kilogram of soil per year.

^{b/} Assumes moisture content of the soil is the average of initial and 1-year moistures.





^{c/} Not Sampled.


^{d/} MPB had been buried under soil stockpile.

ATTACHMENT D
SITE ST71



LEGEND

-  MONITORING POINT
-  VENT WELL
-  ENSR SOIL BORING
-  ENSR GROUND WATER MONITORING WELL

 49-WL-01

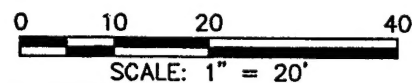


FIGURE D.1

**AS-BUILT VENT WELL,
MONITORING POINT, AND
BLOWER LOCATIONS
SITE ST71**

ELMENDORF AFB, ALASKA

**PARSONS
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Denver, Colorado

TABLE D.1
ST71
RESPIRATION AND DEGRADATION RATES
ELMENDORF AFB, ALASKA

Location-Depth	Initial (July 1993)		6-Month ^{b/} (January 1994)		1-Year (August 1994)		2-Year ^{b/} (October 1995)		3-Year ^{b/} (May 1996)	
	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year) ^{a/}	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)
VW (5'-15')	0.00035	120	NS ^{a/}	NS	NS	NS	NS	NS	NS	NS
MPA-4	0.000086	30	NS	NS	NS	NS	NS	NS	NS	NS
MPA-10	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
MPB-4	0.00032	100	NS	NS	0.00049	140	0.00030	90	0.00006	20
MPB-10	0.0030	840	0.00025	70	0.0015	420	0.00033	90	0.00016	45

^{a/} Milligrams of hydrocarbons per kilogram of soil per year.

^{b/} Assumes moisture content of the soil is the average of initial and 1-year moistures.

^{c/} NS = Not Sampled.